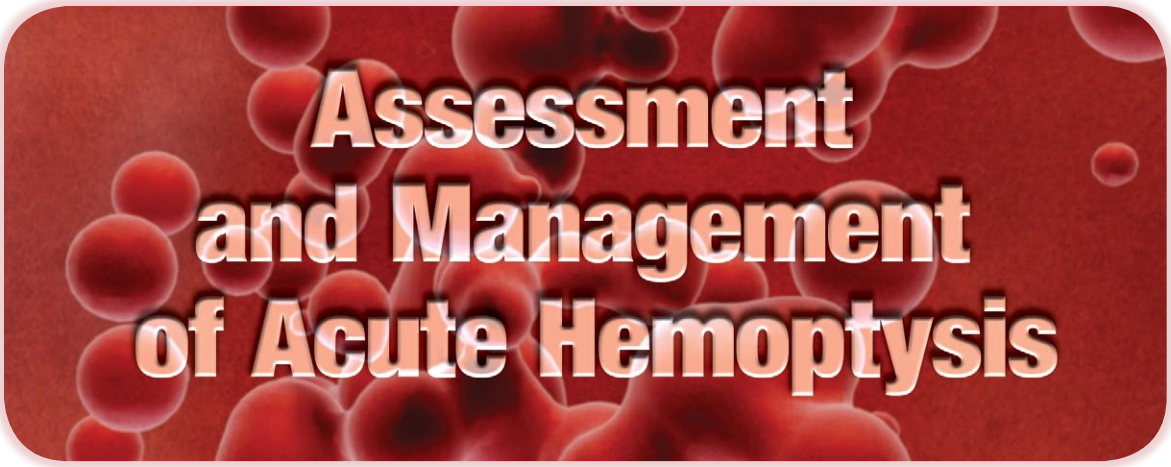

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Expectoration of blood is distressing for patients and physicians alike. Most cases are self-limited and result from an infectious tracheobronchial etiology. However, hemoptysis occurs for numerous reasons, creating a challenge for the emergency physician who must diagnose and manage this entity. This article provides a guide to examination and history-taking, intubation considerations, diagnostic testing, and treatment options in massive and nonmassive hemoptysis.

The diagnosis, evaluation, and management of hemoptysis can pose many challenges to the emergency physician. The word *hemoptysis* comes from the Greek words *haima* ("blood") and *ptysis* ("a spitting"). Simply stated, hemoptysis can be defined as the expectoration of blood. Clinically, however, the presentation of hemoptysis ranges from the commonly encountered blood-tinged sputum associated with an upper respiratory illness to frank blood coughed up by a patient in extremis who is having difficulty maintaining a patent airway. Along with its wide range of clinical presentations, hemoptysis has an even larger variety of etiologies, with little consensus on optimal evaluation and management.

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It should be noted that the phrase "coughing up blood," often used by patients to describe their symptoms, is not synonymous with hemoptysis. The assumption that all expectorated blood originates from the lower respiratory tract is not accurate and can lead to inappropriate evaluation and workup. Examples of pseudohemoptysis include expectorated blood that has its origins in the upper airway or gastrointestinal tract.

MASSIVE HEMOPTYSIS

Hemoptysis can be categorized as *massive* or *nonmassive*, but there are no generally agreed upon parameters to distinguish between the two. Definitions based on the amount of blood expectorated have little clinical utility because quantifying the volume of blood is difficult at best. According to previous definitions, any amount from 100 to 1,000 mL of blood expectorated in 24 hours could be considered massive hemoptysis.[1] A more practical definition of massive hemoptysis would

include a volume and rate of expectorated blood sufficient to impair ventilation and gas exchange. Generally, less than 5% of all cases of hemoptysis are considered to be massive or life-threatening.[2] It is this small percentage of cases that are often the most challenging to emergency physicians, requiring a great deal of critical thinking, aggressive management, and early consultation of various specialists.

CAUSES

Most cases of hemoptysis are caused by superficial mucosal erosions and edema of the tracheobronchial tree arising from an infectious etiology. Most commonly, these cases are self-limited and can be attributed to either acute or chronic bronchitis. Up to 30% of cases are cryptogenic, or have no identifiable cause.[3] By far, the most common causes of hemoptysis are bronchitis, bronchogenic carcinoma, and bronchiectasis.[4,5] Coincidentally, these are also among the most common causes of massive hemoptysis, along with tuberculosis, lung abscess, and pulmonary embolism.[6] The various etiologies of hemoptysis are summarized in the Table.[4]

PATHOPHYSIOLOGY

The site of bleeding in hemoptysis may be difficult to localize due to the lung's extensive blood supply, which derives from two different circulations. The pulmonary artery circulation starts with the pulmonary artery and bifurcates into the right and left main pulmonary arteries. Virtually the entire cardiac output flows through this system at low pressures, generally around 25/8 mm Hg. Because of these low pressures, the pulmonary artery circulation is an uncommon source of massive hemoptysis. However, in those with either acute pulmonary hypertension or a history of this condition, these pressures may rise significantly, playing a more significant role in massive hemoptysis.[6]

The bronchial artery circulation arises from the aorta and intercostal arteries and receives only a small portion of the cardiac output. However, it is a high-pressure system, operating under systemic pressures. Because of this, bleeding from the bronchial circulation tends to be more notable and is responsible for approximately 80% of cases of massive hemoptysis.[7]

INITIAL EVALUATION

History

Despite being generally unhelpful in identifying an exact source of bleeding, a detailed history and physical examination can be helpful in narrowing the differential diagnosis. The chronicity, characterization, and previous episodes of bleeding are important considerations. A patient with a 1-year history of worsening blood-streaked sputum would be more likely to have chronic bronchitis, bronchiectasis, or another indolent

TABLE. Etiologies of Hemoptysis

Pulmonary
Sarcoidosis
Cystic fibrosis
Pneumonitis
Bronchiectasis
Broncholithiasis

Infectious
Necrotizing bacterial pneumonia
Fungal infections
Septic emboli
Pneumocystis (carinii) jiroveci pneumonia
Tuberculosis
Acute bronchitis

Cardiac
Mitral stenosis
Congestive heart failure
Pulmonary hypertension
Eisenmenger syndrome

Iatrogenic
Medication induced
Bronchoscopy
Swan-Ganz catheterization

Neoplastic
Bronchogenic carcinoma
Bronchial adenoma
Kaposi sarcoma
Metastatic disease
Angiosarcoma

Vascular
Pulmonary embolism
Aortic or pulmonary artery embolism
Bronchovascular fistula

Hematologic
Coagulopathy
Thrombocytopenia
Disseminated intravascular coagulation

Pulmonary-renal syndromes
Goodpasture syndrome
Wegener granulomatosis

Vasculitis
Pulmonary capillaritis
Henoch-Schönlein purpura

Other
Hemosiderosis
Thoracic endometriosis
Trauma
Playing a wind instrument

Adapted from Bidwell.[4]

process. On the other hand, a vascular cause may be more likely in a patient experiencing the abrupt onset of cough productive of frank blood. Interestingly, occurrence of hemoptysis with the onset of the patient's menstrual cycle (catamenial hemoptysis) may point towards thoracic endometriosis. Symptoms of fever or chills, hematuria, or weight loss may indicate an infectious source, a pulmonary-renal syndrome, or neoplasm, respectively.[8]

Age is an important consideration in determining the cause of hemoptysis. The aspiration of foreign bodies is more commonly seen in children, while adults younger than 40 years are more likely to have bronchitis or bronchiectasis, and those older than 40 are at higher risk for neoplasm. A social history that documents tobacco use, environmental exposures, and recent travel should also be obtained.[4]

In addition, a patient's medical history may provide important clues to the etiology of hemoptysis. For example, bleeding disorders, renal disease, lupus, AIDS, congestive heart failure, mitral stenosis, and chronic lung disease can all present with hemoptysis. A thorough review of a patient's medication list, specifically for anticoagulant and antiplatelet medications and drugs commonly associated with thrombocytopenia, may provide essential information in the evaluation and management of hemoptysis.[4]

Physical Examination

First and foremost, a complete set of vital signs must be obtained in all patients presenting with hemoptysis. A hypotensive patient who is tachypneic and hypoxic will oftentimes need more urgent intervention before a complete history and physical examination can be obtained.

Many elements of the physical examination can provide diagnostic clues.[2,8] Aspects of the patient's general appearance, such as cachexia, may point to tuberculosis, immunocompromise, or malignancy. A careful examination of the nose and oropharynx is necessary to help exclude upper respiratory causes of pseudohemoptysis. Audible stridor may be noted in foreign body aspiration and upper airway malignancies (or a clot obstructing the airway). A heart murmur may suggest a cardiac etiology such as critical valvular disease (especially pulmonary stenosis). Examination of the extremities may reveal clubbing, a sign of chronic lung disease or neoplasm. Unilateral lower extremity swelling raises concern for deep vein thrombosis and possible concurrent pulmonary embolism. A detailed examination of the skin should also be performed. Rashes may suggest vasculitis, while petechiae or purpura may signal coagulopathy or thrombocytopenia.

ED MANAGEMENT AND STABILIZATION

As always, the evaluation should begin with the ABCs. The most common cause of death with massive hemoptysis is asphyxiation, not exsanguination; therefore, ensuring adequate ventilation with protection of the airway is of utmost importance. The three main goals of management are to prevent aspiration, stop or control the bleeding, and treat the cause. With significant bleeding, two large-bore IV catheters should be placed for volume resuscitation. If the site of bleeding is known, the bleeding lung should be placed in a dependent position to protect the opposite lung.[2] The use of cough-suppressing drugs is controversial and must be undertaken with great caution. Small doses of codeine or morphine may provide some benefit, but these medications may lead to major alveolar accumulation of blood and inadvertent worsening of symptoms.[9]

Blood should be drawn and sent immediately for appropriate diagnostic studies, which might include CBC, prothrombin time, partial thromboplastin time, INR, comprehensive metabolic panel, typing and crossmatching, and arterial blood gas analysis. Urinalysis is also warranted in patients with so called pulmonary-renal syndrome, ie, processes such as Goodpasture syndrome, Wegener granulomatosis, and polyangiitis, that cause both renal and pulmonary bleeding. All coagulopathies should be quickly corrected with transfusion of fresh frozen plasma and/or platelets. If an infectious etiology is suspected, sputum should be sent for bacterial, fungal, and mycobacterial cultures.[2] Serologic studies for more specific diagnoses may also be obtained, such as ANCA antibodies for Wegener granulomatosis or anti-GBM antibodies for Goodpasture syndrome, but results likely will not be available immediately and are unlikely to affect initial management decisions.[9]

It is also advisable to consider early consultation of interventional radiologists as well as those credentialed to perform emergent bronchoscopy. Both may offer definitive care in identifying and ligating the source of bleeding.

ENDOTRACHEAL INTUBATION

If oxygenation and ventilation are compromised, or if bleeding continues at either a large volume or a rapid pace, the patient should be intubated. It is paramount to anticipate a difficult airway and to be prepared to take appropriate measures. Early intubation is generally preferred in all situations where an adequate airway cannot be ensured. Orotracheal intubation is preferred over nasotracheal intubation because a larger tube can be used and the excess length is available for selective mainstem intubation. An 8-mm or larger endotracheal tube should be used, if possible, to allow for subsequent bronchoscopy. A larger tube will also assist in both ventilation and airway suctioning.[6]

Selective intubation of the nonbleeding lung may be necessary to ensure ventilation of the unaffected lung by preventing spillage of blood from the contralateral lung. Selective intubation of the right lung in a patient with a bleeding left lung is easier to perform, primarily because of the alignment of the right mainstem bronchus with the trachea. Given the proximity of the right upper lobe bronchus to the carina, right upper lobe atelectasis may result with right mainstem bronchus intubation. Unfortunately, not all patients have enough cardiopulmonary reserve to provide adequate oxygenation and ventilation with selective intubation of their right middle and lower lobes. Intubation of the left mainstem bronchus may be achieved by placing the patient in the right lateral decubitus position, angulating the endotracheal tube curvature toward the left, and using a coudé catheter to guide the tube.[6] A fiberoptic bronchoscope may also be used to assist in such intubations.[1]

Alternatively, a double-lumen endotracheal tube may be used, allowing isolation and ventilation of the nonbleeding lung while also preventing aspiration. Placement of a double-lumen tube is difficult, even in the most experienced hands. In general, cases requiring double-lumen endotracheal tube placement warrant consultation with a physician experienced in

advanced airway management, and these consultations are best made as early as possible. The patient should be paralyzed if a double-lumen endotracheal tube is used, since any movement can easily dislodge the tube. Moreover, the smaller lumens may cause difficulty with suctioning and may predispose to airway obstruction and clot.[1,10]

DIAGNOSTIC STUDIES AND PROCEDURES

Chest Radiography

A chest radiograph should be obtained in all patients presenting with new-onset hemoptysis. Findings on chest radiography may be normal or nonlocalizing in 20% to 46% of cases, but radiography may be useful in identifying the region of bleeding.[11] Cavitary lesions, tumors, infiltrates, and atelectasis seen on chest radiography may help with localization.

CT and Bronchoscopy

In all patients with hemoptysis who are stable and able to tolerate recumbency, CT should be performed before any invasive procedures are initiated. CT will identify lesions or pathology not visible on chest radiography.[12] The role of CT in imaging the mediastinum and central airways, along with its ability to detect blood clots, bronchiectasis, broncholithiasis, and endobronchial neoplasms, is well established.[13] The type of CT scan (high-resolution, conventional, or CT angiography) should be selected based on history, physical examination findings, and clinical suspicion of underlying pathology. CT angiography is preferred if either pulmonary embolism or pulmonary-vascular fistula is suspected. High-resolution CT, utilizing thinner slices, is designed to evaluate abnormalities that involve the subtle architecture of the lung and often provides incomplete coverage of the lung. It is useful in suspected interstitial disease. For other cases, conventional contrast-enhanced CT of the chest may be utilized.

CT has the advantage of being noninvasive, and it can also be an effective modality for localizing bleeding sites and exploring the cause of bleeding. A retrospective study involving 80 patients with massive hemoptysis compared high-resolution CT to bronchoscopy in determining the bleeding site. High-resolution CT showed no disadvantage compared to bronchoscopy, localizing the bleeding in 70% versus 73% of cases, respectively. However, high-resolution CT was able to identify the cause of bleeding in 77% of cases, compared to only 8% with bronchoscopy.[14] Similarly, in two prospective studies in which patients presenting with hemoptysis underwent both CT and bronchoscopy, CT had a higher yield than bronchoscopy in suggesting a cause for hemoptysis.[15,16] In general, CT can identify various abnormalities, including bronchiectasis, lung abscesses, mass lesions, aneurysms, or pulmonary embolism. If a peripheral lesion or mass is identified, the most appropriate next course of action may be percutaneous biopsy. However, if CT fails to localize the bleeding or provide a diagnosis, bronchoscopy is generally indicated.[13]

In all unstable patients, bronchoscopy should be performed before CT.[17] Rigid bronchoscopy utilizes a larger lumen and allows for greater suctioning ability. It also provides excellent visualization of the central airways, but relatively poor visualization of the lobar and segmental bronchi. Moreover, rigid bronchoscopy is usually performed in the operating room under general anesthesia but can be performed under local anesthesia or conscious sedation in the hands of experienced personnel.[1]

Alternatively, fiberoptic bronchoscopy requires only moderate sedation and can often be performed rapidly at the patient's bedside. It allows for excellent visualization of the lobar and segmental bronchi, which cannot be visualized by rigid bronchoscopy. With rapid bleeding, however, visualization with a fiberoptic bronchoscope can be difficult. The fiberoptic bronchoscope can be passed through the lumen of the rigid bronchoscope, allowing for better visualization of the distal airways by combining the two methods.[1]

TREATMENT

Endobronchial Tamponade

Endobronchial tamponade is one technique that may be used as a temporizing measure to help control active hemorrhage. A Fogarty catheter (size 4 to 7 French) can be passed through the working port of the bronchoscope, advanced into the bleeding segment, and inflated. This will prevent aspiration of blood into the nonbleeding lung, while the endotracheal tube remains in the trachea, allowing for adequate ventilation. More recently, a double-lumen balloon catheter was designed

that allows for the passage of vasoactive drugs through the second lumen.[2]

Topically applied bronchoscopic therapies that may be attempted to slow or stop bleeding include epinephrine, vasopressin, thrombin, or a fibrinogen-thrombin combination.[6,18] Unfortunately, these methods have not been well studied in randomized controlled trials.

Laser Therapy

There has been some success in the management of massive hemoptysis using laser photocoagulation with an Nd:YAG or argon laser to cauterize directly visualized endobronchial lesions—mostly in cases of airway carcinoma with recurrent bleeding. Targeting the lesions with the laser beam can be extremely difficult, however, if bleeding is persistent.[1]

Bronchial Artery Embolization

Another approach often used to control active bleeding is arteriographic embolization. Bronchial artery embolization (BAE) was first performed in 1973 and is currently considered the treatment of choice for most patients with massive hemoptysis.[19] Once the bleeding vessel is identified (Figure 1),[20] a number of techniques may be attempted to control bleeding. Some examples include the injection of gelatin sponge particles or polyvinyl alcohol foam and placement of metal coils. Immediate success rates may range from 64% to 100%, but this can be viewed only as a "semi-definitive" treatment since rebleeding occurs in 10% to 20% of individuals during a 6- to 12-month period.[1,21] A devastating complication associated with BAE is accidental embolization of the anterior spinal artery. Interestingly, the anterior spinal artery may arise from a bronchial artery in approximately 5% of the population; if the artery is embolized proximally, paraplegia may result. Moreover, not all cases of massive hemoptysis involve bleeding from the bronchial arteries, and BAE may fail in cases where bleeding arises from the non–bronchial artery collaterals off the systemic vessels or, as is seen less often, from the pulmonary artery circulation.[1,2,6]

Surgery

A last option for patients with localized disease is surgery. Surgery is generally indicated only in patients in whom rebleeding has occurred post-BAE, those with anatomic variations that preclude BAE, and those demonstrating multiple bleeding vessels on angiography.[9] Contraindications to surgery include diffuse disease (cystic fibrosis, extensive pulmonary tuberculosis), inadequate pulmonary reserve, and inoperable lung cancer. Surgery, however, remains the treatment of choice in those with aortic aneurysms, arteriovenous malformations, bronchial adenomas, and iatrogenic pulmonary rupture (eg, pulmonary artery rupture from a Swan Ganz cathter).[2]

FIGURE 1. Vascular abnormalities seen on pre-embolization bronchial arteriogram of a 25-year-old man with hemoptysis due to tuberculous bronchiectasis. Selective arteriogram shows a common bronchial artery trunk giving rise to a hypertrophied right (arrowhead) and a normal left bronchial artery (arrow).

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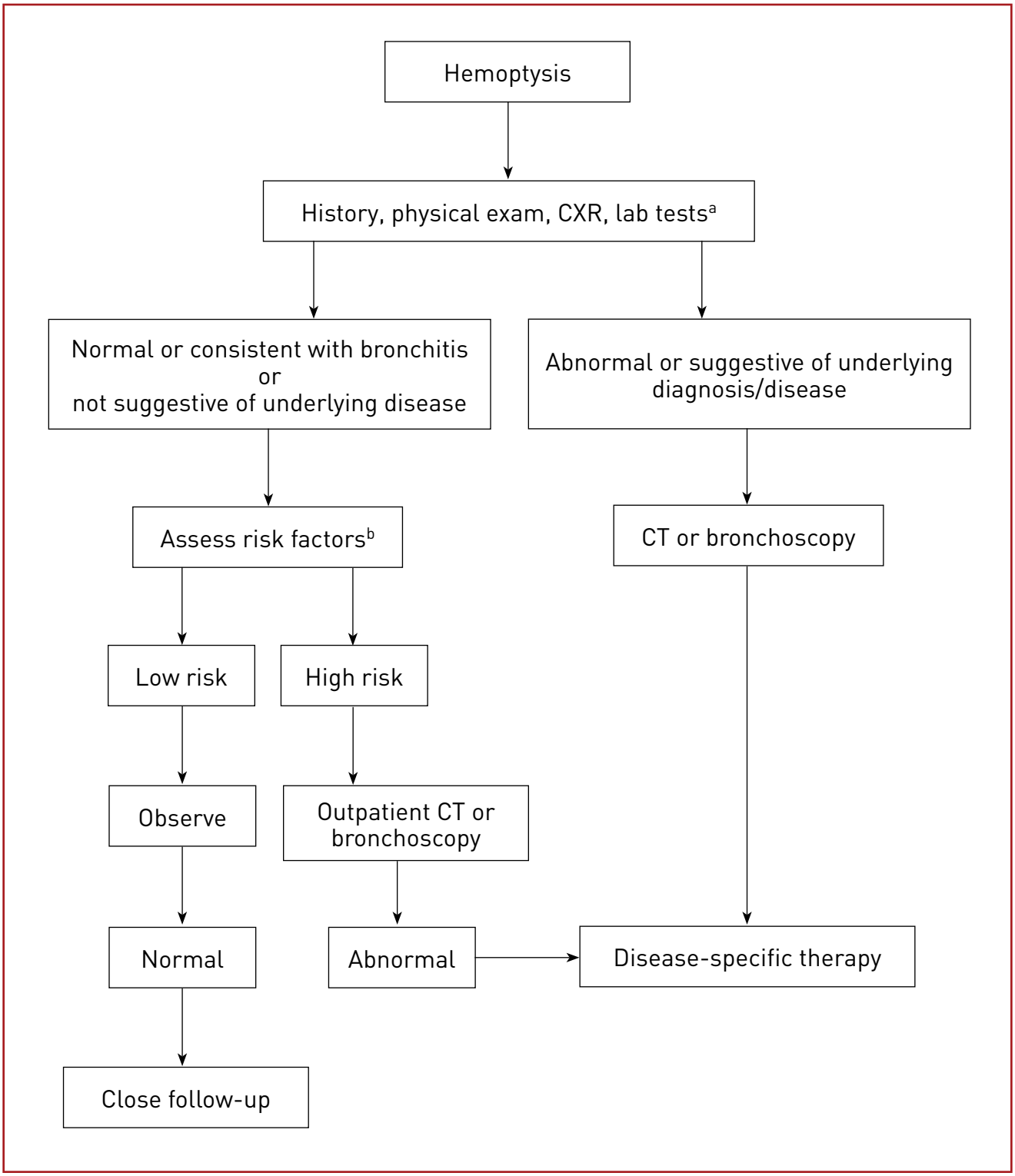
NONMASSIVE HEMOPTYSIS

All patients presenting to the ED with hemoptysis require a baseline evaluation consisting of a detailed history, physical examination, and chest radiograph. In a stable patient, infection is the most common cause

FIGURE 2. Algorithmic Approach to Evaluation of Nonmassive Hemoptysis



CXR = chest radiograph; CT = computed tomography.
[a] Complete blood count, prothrombin time, partial thromboplastin time, international normalized ratio, electrolytes, renal function, urinalysis.
[b] Age >40 years, male sex, >40-pack-year smoking history, hemoptysis lasting >1 week.

of hemoptysis; infectious etiologies account for approximately two-thirds of cases.[4] Along with chest radiography, a CBC, an electrolyte panel, renal function tests, coagulation studies, and/or urinalysis should be obtained at the physician's discretion according to history and findings on physical examination. Moreover, if risk factors for tuberculosis exist, a PPD (purified protein derivative) skin test should be performed. If initial workup, including chest radiography, is normal, the patient's risk factors for malignancy should be assessed. These include age older than 40 years, male sex, greater than 40-pack-year smoking history, and hemoptysis lasting more than 1 week.[4] Patients considered to be at low risk may be observed for recurrence. However, those at moderate to high risk should undergo outpatient CT or bronchoscopy, often with referral to a pulmonologist. If findings on initial evaluation and/or chest radiography are abnormal, CT and/or bronchoscopy should be performed and disease-specific therapy undertaken (Figure 2). Even with mild bleeding, patients with significant underlying disease should be admitted due to their high risk for deterioration.

CONCLUSION

Hemoptysis can present clinically in many ways, and its etiologies are numerous. Clearly, this creates both diagnostic and management challenges to the emergency physician. Although the large majority of cases are self-limited and require little workup, it is crucial to identify those cases that warrant more extensive evaluation and follow-up. Likewise, those cases of life-threatening massive hemoptysis, while rare, often require urgent stabilization and airway control. Unstable patients must be treated aggressively and efficiently, and specialist consultation should not be delayed. Established guidelines do not exist in the management of hemoptysis; thus, each case should be managed with careful assessment of the history, physical examination findings, and risk factors and timely use of diagnostic testing. Maintaining a high index of suspicion in hemoptysis may prevent undesired outcomes in this somewhat unpredictable condition. **EM**

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